size of our machinery, owing to its bulk (*diameter* nearly 30 per cent. greater than equivalent copper); but it will now always act as a check upon the artificial raising of the price of copper.

The high cost of insulating materials renders it unlikely that aluminium with its greater size will ever replace copper in insulated cables. And even as a bare conductor, it is doubtful what advantage in price (together with whatever saving may come from having wires only half as heavy to handle and support) will compensate for the many disadvantages as compared with hard-drawn copper—greater liability to corrosion, difficulty of making joints, less tensile strength (even of aluminium bronze), lack of uniform quality, greater surface exposed to the wind, greater unsightliness owing to size (for trolley wires), &c.

Still, the excessive price of copper which has obtained during the last two years, and indeed till a few months ago, has led to the putting down of between one and two thousand tons of bare aluminium conductors for electric-power transmission—chiefly in America, and for very high-tension, long-distance schemes—schemes, in fact, in which the cost of the lines represents the greatest proportion of the whole expenditure.

The experience as to the behaviour of aluminium already gained from these installations is very valuable, as may be gathered from a perusal of two recent papers—one read by Messrs. Perrine and Baum before the American Institution of Electrical Engineers, and the other by Mr. Kershaw before our own similar Institution. The former writers find that, owing to a large temperature change in the elastic constant, the true coefficient of expansion of the new metal is not applicable in calculations of stresses in suspended wires having a given sag, the apparent temperature effects being much less than those calculated. Again, in the latter paper it is suggested that aluminium will not weather so well in this country as in the drier climate of America. It would seem also as if, while good soldered joints are quite possible with the metal, only welded or "burnt" joints involving no solder are durable out-of-doors, the metal being so highly electropositive, and the alloys formed near soldered joints unstable. Mechanical joints are generally used in America. The McIntyre joint is made by slipping the ends into a flat aluminium sleeve, the whole being then twisted round twice or thrice. It is doubtful whether such joints retain their initial high conductivity, in view of experience with similar joints in telegraph work. As an electrical conductor, then, it is only in those rare cases where conducting power for a given weight is wanted, *irrespective of volume*, that aluminium is without question the best material to use.

For structural purposes, the new metal has up to the present proved a little disappointing. In the first place, the pure metal is useless, being too soft. This, however, was to be expected. Pure iron is also soft. The alloys with copper up to a density of 3 include some which seem fairly strong; but the fact that cycle frames are still made of steel shows that, where strength and lightness are required together, and cost is not of great moment, steel can still hold its own, apart from its relative cheapness. No doubt, however, there is yet much to be learnt about the metallurgy of the alloys with copper, and with other elements also—nickel, tin, magnesium, &c.

A considerable demand for aluminium has grown up in connection with the manufacture of a great variety of small articles, instruments, &c. The most important uses of the metal from a commercial point of view are based upon the activity of its reactions at a high temperature. Added in small quantities to molten iron just before a cast is made, the metal is rendered more fluid and the quality of the casting thereby improved.[1] This result appears to be due to the reduction by the aluminium of any iron oxide which may be present, and to the raising of temperature of the iron itself by the heat of the action. It was stated by Swan, in a recent presidential address in Glasgow, that this use of the metal formed one of the chief outlets for the 6000 odd tons of aluminium which were manufactured last year.

The Goldschmidt process, by which the most intense heat can be produced in any required amount at a given point also depends upon the same fact, that aluminium can reduce iron oxide with energy to spare. A mixture of finely-divided aluminium and iron oxide, known as "thermit," can be ignited by a suitable fuse, and results in a quantity of molten iron heated far above the melting-point and protected from combustion by a layer of alumina. This iron, being so very greatly superheated, will serve for a variety of purposes, and its quality can be varied as required by suitable additions to the "thermit." This process was lately described and demonstrated at the Royal Institution by Roberts-Austen,[1] to whom, indeed, it is largely due. It has been applied to the welding of rail joints in position for electric traction, and to the repairing of broken and of faulty steel castings. The process has, in fact, many of the possibilities of the electric furnace, without the drawback of being dependent upon a fixed and costly electrical installation.

THE OCTOBER ORIONIDS.

IN many previous years the Orionid radiant has been well defined at a point very close to, if not coinciding with, the position of the star ν Orionis (mag. 4½). The shower was very successfully observed by Prof. A. S. Herschel on about October 18–20 in the years 1864, 1865 and 1867, when the centre of divergence was found to be at $90^\circ + 15^\circ$. A number of observations were obtained at Bristol in 1877, 1879, 1887 and other years, and the radiant derived from them was at $91^\circ + 15^\circ$. The meteors of this shower belong to the swifter class, and they leave streaks which enable their directions of flight to be so correctly noted that the centre of emanation not only appears sharply defined, but can be very accurately located. The streaks frequently linger for two or three seconds and will sometimes very perceptibly brighten up after the heads of the meteors have vanished.

The observations in 1900 and 1901 made at Bristol show that the true Orionids were feebly represented and that, in fact, the annual shower-meteors from the old position at ν Orionis had been supplanted by a more active radiant of Geminids agreeing in place with the star ξ Geminorum (mag. 3½). On October 23–27, 1900, and October 20, 1901, I recorded about twice as many meteors from $100^\circ + 13^\circ$ as from $91^\circ + 15^\circ$. The observations were not very numerous, but had they been far more complete there is no reason to suppose that the conclusions would have been materially affected.

The difference of 9° in the positions of the radiants at ν and ξ Orionis is sufficiently large to be immediately detected by meteoric observers though their materials are merely eye estimations. The latter are, however, unusually trustworthy, not only in the case of the Orionid display, but also in regard to some of its bordering and contemporary showers which furnish similar objects. The flash of a meteor's head as it darts rapidly along in a state of combustion attracts the eye to the point of appearance, and the streak which immediately glows along the path enables the observer to fix the apparent direction of flight with almost instrumental precision.

In the *Monthly Notices* for December 1895 (vol. lvi. p. 74) I mentioned the γ Geminids as one of the most prominent companion radiants of the Orionids and gave

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[1] See "The Relations of Aluminium to Iron," by Godfrey Melland (*Proc.* Staff. Iron and Steel Inst., 1900).

[1] "Metals as Fuel," Royal Institution Lecture (NATURE, August 8, 1901).

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the mean position of the centre as 97°·1 + 15°·2 from thirteen observations by various observers. In the "General Catalogue of Radiant Points" (*Memoirs* R.A.S., vol. liii.) this shower forms No. lxxix. and the radiant is given at 96°·6 + 16°·5, based on nineteen observations. But there is now reason to believe that these positions are two or three degrees north of the correct place and that instead of corresponding with the star γ Geminorum it really agrees with ξ Geminorum. Certainly in 1900 and 1901 the most conspicuous shower of rapid streak-leaving meteors was directed from 100° + 13°, the position of the star ξ Geminorum for January 1901 being α = 6h. 39m. 44·0s., δ = 13° 0′ 9″·1 +.

It will be interesting to watch future returns of the October meteors in order to ascertain whether the formerly strong shower at ν Orionis has only been temporarily weak during the few past years or whether it has finally withdrawn in favour of its easterly companion radiant at ξ Geminorum. Possibly the swarm of Orionids has been recently disturbed by planetary attraction and the node displaced sufficiently to bring about a change of 9° in the radiant. If so, the principal meteoric display of October must henceforth be known as Geminids instead of Orionids. But the more probable supposition appears to be that the Orionids have been very scantily distributed along those parts of their orbit traversed by the earth in late years, whereas the neighbouring shower in Gemini has been so much stronger than usual as to form the principal display of the epoch. The Orionid system used to present itself with considerable regularity like the August Perseids, though it exhibited variations of strength in part no doubt attributable to the different atmospheric conditions prevailing, to the position and age of the moon and to other circumstances capable of affecting the visible aspect of the stream.

W. F. DENNING.

ARMOUR-CLAD WHALES.

AMONG the many wonderful palæontological discoveries that have startled the scientific world during the last few years, none, perhaps, is more unexpected than the revelation that the ancestral whales were protected from attack by a bony armour analogous to that with which the armadillos of South America are covered. Scarcely less marvellous is the fact that vestiges of this ancient coat of mail are still borne by such familiar cetaceans as the porpoise and its near relative the Japanese porpoise (*Neophocaena phocaenoides*), the latter species being distinguished by the absence of a back-fin. That creatures like the modern pelagic whales and porpoises, or even the river dolphins, could ever have been invested with a complete bony armour is, of course, an absolute impossibility. The rigidity of such a panoply would have interfered far too much with the mobility of their supple bodies, while its weight would have impaired their buoyancy. Consequently it is necessary to assume that in even the earlier representatives of these types the armour must have been in a condition of degradation and elimination, so that we must go back to still earlier forms to find it in its full development. As every one knows nowadays, whales and dolphins trace their ancestry to land animals, and it appears highly likely that when such ancestral creatures began to take to an amphibious life on the sea-shore, or at the mouth of a large river, they may have developed a dermal armour which would serve to protect them alike from the breakers and from the attacks of sharks and other marine monsters. For the idea that the terrestrial ancestors of the cetaceans were clad in armour cannot for a moment be entertained, since the primitive mammals were not so protected and the American armadillos afford an instance of the development *de novo* of such a bony panoply at a comparatively recent epoch.

Years ago the late Dr. H. Burmeister described a porpoise from Argentina as *Phocaena spinipinnis*, on account of its possessing a number of spiny tubercles embedded in the skin in the neighbourhood of the back-fin as well as on the fin itself. "Some small spines," he writes, "begin in the middle of the back, at the distance of 25 centimetres in front of the fin, as a single line of moderate spines; but soon another line begins on each side, so that in the beginning of the fin there are already three lines of spines. These three lines are continued over the whole rounded anterior margin of the fin and are augmented on both sides by other small spines irregularly scattered, so that the whole number of lines of spines in the middle of the fin is five." In a section of the skin of the back-fin the tubercles are distinctly seen, many of them being double.

Similar tubercles were described on the back-fin of a porpoise taken in the Thames in 1865; and quite recently a row of no less than twenty-five well-developed tubercles has been detected on the front edge of the back-fin of a fœtal porpoise, these tubercles being nearly white and thus showing up in marked contrast to the dark-coloured skin. Even more distinct are the tubercles in the skin of the finless back of the Japanese porpoise, where they form several rows of polygonal plates.

In a fossil porpoise (*Delphinopsis freyeri*) from the middle Tertiary deposits of Radoboj in Croatia, the tubercles were still more strongly developed, and formed a series of regularly arranged and parallel rows in the neighbourhood of the back-fin. They clearly indicate one step from the modern porpoises in the direction of a species provided with a functional bony armour in this region of the body. Between the extinct Croatian porpoise and the much more ancient whale known as *Zeuglodon*, some part of whose body was protected by a bony armour as solid as that of the giant extinct relatives of the modern armadillos, the intermediate links are at present unknown, although they may turn up any day. *Zeuglodon* was first discovered in the early Tertiary strata of the United States, but its remains have subsequently been obtained from the equivalent deposits of Egypt and elsewhere, and in early times it was probably the dominant cetacean of the world. Years ago there were discovered with the bones of the internal skeleton of this whale a number of bony plates which originally formed a dermal armour; although they were regarded as belonging to a species of leathery turtle and as having nothing to do with the whale.

But in microscopic structure, as well as in their arrangement, these polygonal bony plates differ altogether from the armour of the leathery turtle; while their structure is generally similar to the undoubted bones of *Zeuglodon* with which they are found in association. Moreover, a fragment covered on one side with armour of this type has been discovered which cannot, apparently, be any part of the shell of a turtle, but which may well be the back-fin of *Zeuglodon*. And as the aforesaid bony tubercles of the porpoises are always found on or near the back-fin, it is a safe assumption that in *Zeuglodon* the entire dorsal fin, as well as some portion of the back, was covered with a complete tessellated armour of bony plates.

The majority of the living toothed whales (inclusive of porpoises and dolphins) are furnished with a dorsal fin, and it is therefore reasonable to suppose (apart from the evidence of the specimen just referred to) that *Zeuglodon* was similarly provided; and if this be so, that cetacean was evidently a pelagic creature. For the function of a dorsal fin is to act as a kind of keel in maintaining the balance of the body, this appendage being most

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